Real-Time Detection of Car and Pedestrian for Visually Impaired People

Abstract—In unfamiliar places, vision impairment restrains the movement of the person. Technological aids are of critical importance as they Enhance the quality of life and independence of people with visual impairments. The visually impaired person cannot distinguish between the objects. Existing systems use deep learning models which are difficult to implement in hardware and upgrade. These systems are bulky and expensive. This paper proposes a computer vision-based model to detect two objects, person and car, and raise a voice alert. In this work, ORB feature descriptor is used. The feature vector dimensionality is reduced by using the elbow method to decide the count of K-means clusters. For faster object detection with reduced hardware, the dimensionality is further reduced by using Principal components analysis. The system is evaluated on 6 different classifiers viz Decision tree, SVM-OVO, SVM-OVA, KNN, Logistics regression, Random forest. The testing accuracy of this classifier is respectively 89%, 81%, 81%, 85%, 81%, 90%. The classifier output is converted into an audio signal notification about the detected object.

Keywords— Machine Learning, Object Detection, Computer Vision (OpenCV), PCA, Blind Assistant.

I. Introduction

People with blindness have to face major challenges in terms of ultimately impacting their ability to integrate into society through education, employment, and independent living. Globally, the total number of blind people are 285 million, 39 million are visually impairments . which equates to 20% of the Indian population [1]. It is difficult for them to navigate on their own, especially when they are on their own. Even access to basic daily needs is largely dependent on others. Most of the blind or visually impaired people have access to basic daily needs using white stick or white cane because of their low cost.

For detecting foot level obstacles the visually impaired people use the traditional white cane. That cane gives maximum range of one meter. This is the reason why Blind people Injuries to the face or upper body result from bumping into dangerous overhanging branches, signboards, and parked vehicles. They are unable to recognize persons, vehicles or obstacles. This makes them anxious and severely limits their independence of movement.

Therefore, achieving independence, effectiveness, and efficiency among people with disabilities by using real-time assistive devices that can detect its surroundings environment in fine detail in Environments both indoors and outdoors, day or night can be challenging.

To assist Several electronic devices are available for visually impaired people introduced such as wearable assistive devices, handheld devices, navigation systems. Despite this, most existing systems suffer from two problems: the devices offered are expensive, the majority of blind people belong to low-income groups, and the proposed systems have limited capabilities and services. Therefore, a comprehensive framework must be designed that integrates With computer vision, all the available sensors and technologies can address these problems.

Navguid [2], Navi [3], Mancini Et Al.: Mechatronic System [4], Wearable Haptic Device [5], Spectacle Prototype [6], Novel Visual Aid System [7], Wearable Device For Indoor Imminent [8], Smart Google Glass [9], RFID-Based Assistive Glove [10], Smart Assistive Navigation [11], this are some Wearable assistive system/devices.

NavGuide device can detect obstacles, wet floors, and ascending stairs more efficiently than white canes and it provides a solution to exiting ETAs present four fundamental deficiencies. 1)Slippery floors can be avoided with the detection of wet floors. 2) A tactile and auditory sense will receive prioritized and simplified information from this device. 3) In this manner, users' tactile and auditory senses receive prioritized, simplified information. 4) The device is also lightweight and inexpensive. [1] NAVI is using the range information along with the color information to detect obstacle-free paths yields a robust and efficient system that incorporates both range information and visual information [2]. The Mechatronic System device is focused on an assistive system based on monocular vision Walking, jogging, and other physical activities running in outdoor environments. The vibration motor is connected to the BLE device on gloves. Also visible is the camera attached to the user's chest [9].

Wearable Haptic Device based on RGB-D camera, CUFF device, two Maxon DC Motors, two VELCRO belts, In an unknown indoor environment, an actuator powered by 12V battery provides normal force cues as well as tangential force cues for obstacle avoidance with a processing unit [3].

Spectacle prototype assistive devices are designed to help people with vision impairments navigate independently their environment. A pothole detection is also a system for detecting obstacles were developed. The obstacle is identified in each direction using three ultrasonic sensors, and including front, left, and right. A convolutional neural network (CNN) and an ultrasonic sensor are also used Road surface potholes can be detected using this method. The CNN runs on an embedded controller to identify obstacles on the road surface made with a raspberry pi [4].

Aid System Novel based for visually impaired person may use an eyeglass set as a support. These devices have the following features. 1) Navigate indoors and outdoors with hands-free, wearable technology that is low power, low cost, and compact. Raspberry Pi 3 Model B+ is ideal for the low-end processing power of complex algorithms. 3) A camera and ultrasound sensor combination offer dual capabilities for detecting and measuring objects. 4) Integrated reading assistant that enables blind individuals to read documents using images-to-text conversion [5].

Wearable Device For Indoor Imminent With Region-Based Ground Segmentation used Real-time object detection and collision-free path tracking with a RGB-D (RGB-D) camera and an Inertial Measurement Unit (IMU) [6] , 3D region proposal Ground segmentation can be reduced by a significant amount with this module, as it can flexibly develop the potential ground region and minimize the impact computational costs

Smart Google Glass system is a Wearable, portable, and real-time, the system is designed to work in an emergency situation. This system uses the camera in Microsoft's Custom Vision API from Azure Cognitive Services is used for smart glasses to capture images of the surrounding environment to be analyzed. Visually Impaired People, wearing Google Glass, hear the speech output generated by the Vision API [7].

RFID-Based Assistive Glove is based on Indoor navigation system that provides end-to-end solutions makes use of a variety of localization technologies to assist blind users in finding specific objects. and for There are three layers of localization: Wi-Fi, Bluetooth, and RFID [8].

Smart Assistive Navigation based on Smart Glasses and smart shoes fit over a person's eyes to provide them with mobility and sensing of their surroundings to help people with visual impairments [9]. IR (Infrared) Sensors, Raspberry Pi cameras, and Raspberry Pi modules are used in both system to detect obstructions so that an audio alert can be provided to users as well as communicating important information to them so that they can navigate easily in both systems [9].

Handheld device is NavCane [12], Cognitive Mobility [13], obstacle detection using LiDAR [14].
Navcane compared to machine vision systems, the prototype is more cost-effective as well as low-power embedded device. It used Ultrasonic sensors, module with GPS , Gyroscope, Vibration motors , sensor for wet floors, and Battery comprise this device along with a radio frequency identification reader. this aids device recognition the objects in an indoor setting [12].

Cognitive Mobility novel framework for assessing the cognitive factors affecting human locomotion, as well as their utilization of new tactile technologies for mobility assistance. Absent a tangible wearable refreshable device capable of triggering tactile stimulation, it is difficult to acquire spatial knowledge that uses a perception-movement platform will enhance your sight. SSUDs (sensory supplementation and replacement devices) or sensory replacement devices (SSDs), Various smart canes (Sonar, UltraCane, TomPouch) and robots (Robotized, UltraCane, TomPouch) can be seen in the image above). used in this device [13]. obstacle avoidance using LiDAR This a lightweight, efficient, robust, and cost-effective obstacle detection system can now be implemented on a smartphone that is easy to use, small in size, and can be carried easily, using low-cost deep learning techniques [14].

Navigation system-based devices are LSD-SLAM technology system [15], assistive navigation system [16],
V-Eye [17], smartphone-centric tracking system [18], Navigation System For Visually Impaired People [19], Robotic navigation aid (RNA) [20], smart multisensory [21], smart cane [22], Remote Vision [23] Wearable Device Assist VI People [24], Indoor Navigation System [25].
LSD-SLAM technology system [15], and System that utilizes wearable sensors to offer real-time localization and interprets events from social media networks to address the issue of blind mobility. The system allows users to interact with the world physically. Through the incorporation of wearable sensors, such as cameras, proximity sensors, accelerometers, and gyroscopes, it can be possible to enhance the environment at a proximity level by providing location awareness (such as obstacle detection and avoiding) [16]. V-Eye- the system is a using both global positions and results from scene-understanding, this monocular camera provides obstacles warnings and navigation information, such as location and orientation data. Users gain knowledge of these data with audio feedback. By utilizing VB-GPS's global localization functionality, the system fulfills these requirements and by segmenting single camera images, we can gain a better understanding of scenes [17].

Smartphone-centric tracking system use of Sensors and inertial sensors are integrated into a smartphone camera. Navigation systems like this can also provide tracking systems with direction estimates and controlled indoor environments as well as in real-world environments outdoor installations the hardware used in this device Wi-Fi, Using RFIDs, ultrasound, Bluetooth, and other devices, some models are directly based on landmarks (e.g., RFIDs, Ultrasounds). The Ego-Motion of individuals has been studied using inertial measurement units (IMUs) [18].

This navigation system is accessible to people with visual impairments all over the world anytime and anywhere. Performance testing was focused on the main characteristics of the mobile links, which include bandwidth, latency, link outages, and packet loss since these characteristics directly affect navigation system performance [19]. A transmission link is needed by the navigation system to guarantee that data is delivered as quickly, efficiently, and with the least amount of delays, losses, and interruptions (disconnections). The link also needs to support enough bandwidth to simultaneously deliver video, voice, and GPS data. Considering the low bandwidth, the assessment shows the 2G link is unsuitable. Due to its high and variable latency, the 2.5G link cannot be used [19].

Robotic navigation aid (RNA) By using a new VIO method called DVIO, you can calculate RNA's 6-DOF pose. A better degree of pose estimation can be achieved by using RGB-D camera depth data. Pose of the 3-DOF RNA is estimated via a VPS on the floor plan to aid in navigation [20]. Based upon Ego motion is estimated using DVIO-PFL by VPS to estimate the pose. It improves the accuracy of pose estimation. VPS is developed and evaluated in real-world experiments with RNA prototypes to develop and validate a navigation system based on VPS [20].

Smart Multisensory Various approaches to multisensory architecture are discussed, which could enable blind people to accomplish urban mobility tasks. An adaptive signal processing system enables the device to utilize multi sensors. It is used sonar module MS6501, multisensor probe, infrared motion sensor, microcontroller, Polaroid electrostatic transducers, e Napion MP sensor,(low-cost device assuring)to build system [21].

SmartCare assist Individuals who are blind are able to travel independently indoors with assistance. Indoor semantic map creation, navigation, wayfinding, obstacle avoidance, and a multimodal user interface (speech, audio, and haptic) are among the ISANA functionalities [22]. As a valuable tool to assist blind users with indoor navigation, our research with blindfolded and blind subjects demonstrated that our technology can provide situation awareness for the user's surrounding environment and navigation aids [22].

Remote Vision system depends on video frame rate, video image frame rate and it was simulated to Analyze how frame rate affects video images depend upon Video footage showing pedestrians moving around dynamically in an environment with stationary environmental hazards displays performance in visual detection [32]. Two different video frame rate variations were used in the performance evaluation: 25 and 2 frames per second and using some microphone, speaker, digital camera, GPS receiver, EL compass is required to build this system [23].

Wearable Device Assist VI People used based Computer vision and sensor-based approaches are used to facilitate the mobility of people with vision impairment indoors and outdoors. Hardware components include a FEZ spider microcontroller, GPS, camera, compass, gyroscope, music, microphone, and gyroscope [24]. A multi-sensory system was integrated into the software to provide accurate navigational information and support a navigational system. A measurement method proposed in this study is able to give us an approximate estimate of the distance between the user and the object [24].

Indoor Navigation System is An end-to-end indoor navigation system that helps blind users locate precise objects using various localization technologies. Wi-Fi, Localization techniques based on Bluetooth and RFID can be used employed in the localization process, which consists of three tiers. The users do not need any additional types of equipment to facilitate navigation using the proposed integrated indoor navigation system [25].

Technology has contributed to such a number of innovations in Wearable assistive system, Handheld device, Navigation system under the Electronic travel aid ETAs. A very few ETAs have been successful in attracting users [26]. There appears to be an interest in technology aids among people with visual impairments; therefore, there is a need to improve these technologies.to make them more useful and acceptable for visually impaired people. Usability, interfaces, and information overload are top concerns for users of ETAs. The majority of these technologies have some limitations, including infrared and ultrasonic methods that have limited range capacities. The use of lasers on third parties may harm them if they are hit directly in their eyes or on other parts of the body [17].

Existing ETAs use primarily variable frequency audio patterns to represent surrounding environments. With ETAs, the either cognitive and perceptual load is transferred to the subject or the subject is relieved entirely of it [18].
ETAs with multisensory inputs are incredibly useful, however, they are complicated to use, bulky and heavy. And The interface of some ETAs is simple, but the capabilities are limited. Perceptual effort increases with continuous usage may cause tiredness and fatigue [18]-[27]. Moreover, reduced reaction time results in fatigue [28].requiring a more rapid response. Blind elderly individuals may require a faster response [29]. Short-range devices are difficult for them to operate [27]-[30]. The user interfaces of some ETAs are quite good with their functions. As we mentioned above, the program has usability issues. Users do not seem to be well informed by ETA developers. potential users [33].

To find out what their needs and expectations are, we conducted a survey. The persons with visual impairments, their rehabilitation professionals were interviewed. They gave us their preferences regarding usable functions, user interfaces, physical interfaces, carrying methods, and aesthetic aspects they would like for an ETA [31].

The current aids they use also needed to be suitable for their mobility difficulties. There were several expectations from the ETA. The design concept seemed to have some consensus, however, including the following (1) correct information about the surrounding area, (2) simplicity, (3) aesthetic acceptability, (4) safety, (5) availability, (6) portability, and (7) affordability. White canes are mostly useful but there is a limitation in providing insufficient ground-level information, according to most subjects. A total of 28.07% of participants said they were anxious about colliding with objects above their knees or by accident. Three out of four participants stated that they used a white cane to perceptual efforts. More than 8% of subjects complained of injuries caused by and manhole covers, floor plates, and bars. Also in this survey, 23% of participants face have had slip-and-fall accidents caused by wet floors. For its mobility assistance functions, augmented canes were preferred by 59% of the participants. Furthermore, this survey examined the effects of augmentation on functional abilities. Environments indoors and outdoors in the real world. These environments are commonly observed to have a variety of obstacles and we examined their possible distribution along the travel path. And this survey is conducted at the Vishwakarma Institute of Technology campus (Pune).

II. METHODOLOGY

This paper presents a method to detect a plying car and a person walking on the road. The block diagram of the proposed detection system is shown in Fig.1.

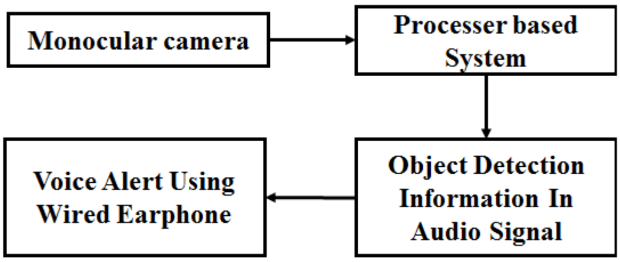

Fig.1. Block Diagram of the System Architecture

A monocular camera captures a real-time image and provide or feed it is an input to the processor-based system to detect the object. The information of the detected object is conveyed to the audio signal for user interaction, via wired earphone. The proposed system can be implemented applied any garment.

A. Dataset Collection and Preprocessing.

Total 9000 images are used for implementing this application, and the distribution of 9000 images is shown in Table .1.

Table.1.Datasets Classes.

Sr.no	Type	No of Images	Classes.
1.	Car	3000	0
2.	Person	3000	1
3.	Negative	3000	2

There are two classes in positive images that is car and person out of the collected dataset, 60% images are obtain from internet [34]-[35] , and 40% images compiled by author.

All the images are converted into the grayscale, and then resize to the size of 280 x 430 pixel.

Fig. 2. Sample images in the dataset

B. Feature Description

FAST Oriented and Rotated BRIEF (ORB) is a fast feature detector. The ORB based on the FAST key point detector and the binary robust independent elementary characteristics (BRIEF) descriptor.

The features from accelerated and segments test (FAST) algorithm is used to detect key points. If a pixel is significantly different from adjacent pixels, this is most likely a key point as shown in Fig.3.

$$\theta = arctan\left[\frac{m_{01}}{m_{10}}\right] = arctan\left[\frac{\sum_{a,b} bI(a,b)}{\sum_{a,b} aI(a,b)}\right] \quad (1)$$

After extracting the orientation points from FAST, ORB calculates a descriptor for each point using the BRIEF algorithm. BRIEF is a one-binary vector handle whose vector consists of the numbers 0 and 1.

$$m_{pq} = \sum_{x,y} x^p\, y^q\, I(x,y) \quad (2)$$

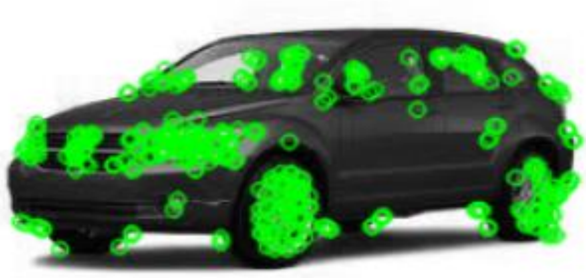

Fig. 3. ORB Feature Descriptor

ORB feature descriptor was applied on all images in the dataset to get the final feature vector.is as shown in Fig.4.

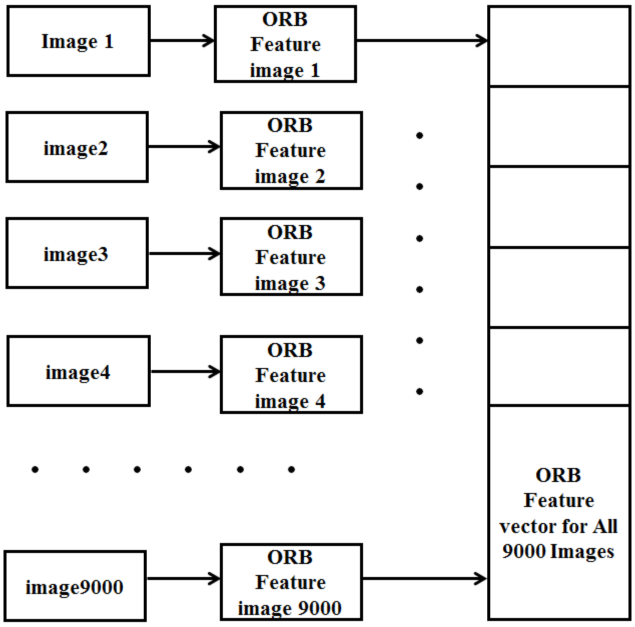

Fig. 4. All ORB Descriptor

The total dimensions are 32, and 3 million descriptors are obtained, and the size of feature vector is around 3 million x 32.

C. Dimensionality Reduction.

This approach is optimized to reduce the size of feature vector. Dimensionality reduction is used to reduces computation/training time, and to run it on portable system. It also helps to eliminate duplicate features, if any.

k-means clustering, and principle component analysis are jointly used to reduce the dimensions of feature vector.

For K-Means clustering the number of clusters is five, that was chosen based on the elbow method.

The K-Means clustering feature vector is divided into 5 cluster as shown in Fig.5.

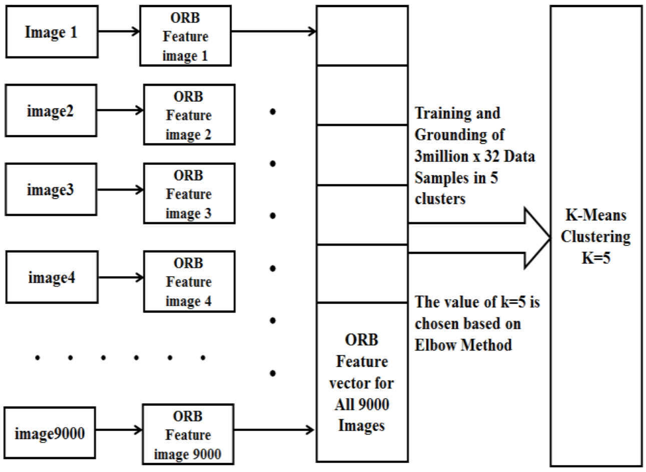

Fig. 5 Training and grounding large feature vector with k-means clustering method

ORB feature of each image was predicted by using k-means classifier. Histogram is the output of k-means classifier, was normalized to reduce or remove the bias values from histogram as shown in Fig.6.

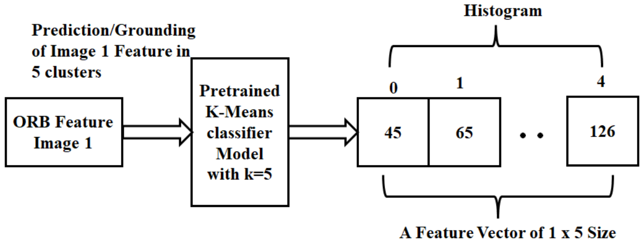

Fig. 6. Grounding of ORB feature

It was applying on all 9000 images, and the reduced feature vector size is 9000 x 5 is shown in Fig.7.

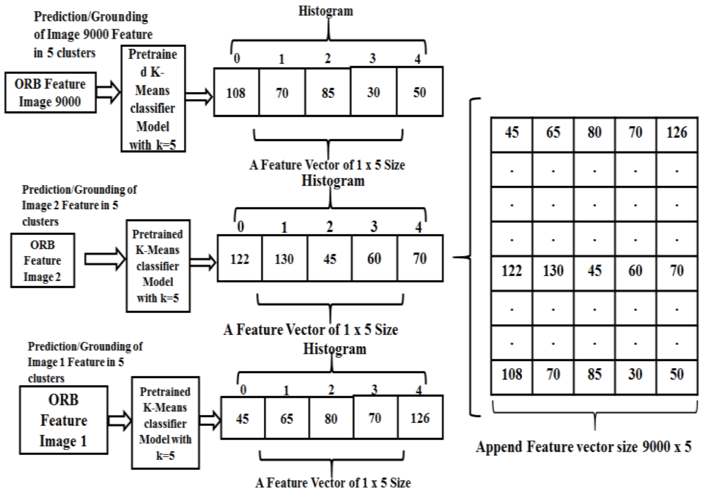

Fig. 7. Feature vector compilation by using pretrain K-Means classifier model

Dimensions of this feature vector was further reduced to 9000 x 3 by using principal component analysis. That principal components analysis, as shown in Fig.8.

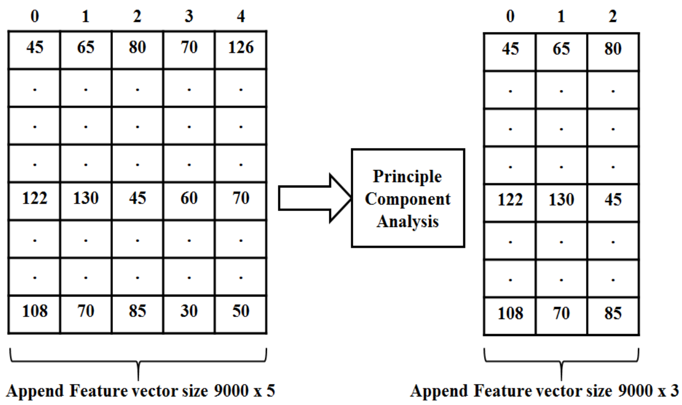

Fig. 8. Compilation of final feature vector by using PCA

And then final feature vector size is 9000 x 3, this feature vector is for train the model.

D. Classification and detection.

Array of 5 classifier was trained with the optimized feature vector.

I. SVM, II. Logistics Regression, III. KNN, IV. Decision Tree, V. Random Forest.

Support Vector Machine (SVM) is a supervised machine learning algorithm, this algorithm is used for single as well as multi-classes.

$$h(x_i) = \mathrm{sign}\left(\sum_{j=1}^{s} \propto_j y_j k(x_j, x_i) + b\right) \qquad (3)$$

in the SVM for multiclass classification we are using the OVO (one vs one) algorithm it is a binary classifier .OVO is a basic use for multiclass classification and it will classify the classes based on binary classification. it will divide the dataset into the binary dataset and in OVO method divide the dataset into one dataset. With the help of SVM (OVO), the proposed model attained an accuracy of 81%, and with the help of SVM (OVR) proposed model attained an accuracy of 81%.

LR (logistics regression) is the supervised machine learning algorithm it is not suitable for multi-classes classification it is only working on the single-class classification. Because LR is the binary classifier.

$$p = \frac{e^{a+bx}}{1+e^{a+bx}} \tag{4}$$

The probabilistic value ranges in the form 0 and 1. And the outcomes are categorized in the form of 1 and 0 . with the help of LR proposed model attained a training accuracy of 81%.

The K-Nearest Neighbor method is based on a supervised machine learning technique. As the name of the classifier, the K is the nearest data point to predict the class.

$$d(a, b) = \sqrt{\sum_{i=1}^{n} (a_i - b_i)^2} \tag{5}$$

The principle of KNN checks the points nearest in the space form a new data point that is a selection of k. The k value is chosen by the error curve. With the help of KNN proposed model attained an accuracy of 89%.

The Decision Tree, for instance, is an example of a supervised machine learning algorithm, which makes decisions based on rules, much like humans.

$$E(S) = \sum_{i=1}^{c} -p_i \log(p_i) \tag{6}$$

It is helping to determine the splitting based on entropy information gain. The main advantages of the decision tree algorithm are that it helps all possible values. Using the decision tree classifier the system gets 89% of testing accuracy.

For solving the classification and regression problem the RF (Random Forest) is a good machine learning approach. It is the technique that the combining the multiple classifiers for solving the complicated classification and regression problem. The RF method is made up of multiple numbers of decision trees.

$$Gini = 1 - \sum_{i=0}^{c-1} [p_t]^2 \tag{7}$$

The outcome is determined by the RF algorithm based on the predictions of the decision trees, as the number of trees is increasing the precision of output is improves. With the help of RF proposed model attained an accuracy of 91%.

Algorithm 1: Feature Extraction Dimensionality Reduction

Input :- Image
Output- Reduced Feature Vector

1. Initialization :
2. Loop process:
3. a = number of 9000 images in directory
4. **for** (i =0, a == i, i++)
5. $m_{ab} = \sum_{p,k} p^a k^k I(p, k)$: ORB features 3 million x 128
6. Transform using K-Means with k =5
7. Normalization
8. Append to Feature Vector (9000 x 5)
9. **end**
10. Fit PCA (N_componant = 3)
11. $\sum_{i=1}^{N} \| x_i - \tilde{x}_i \|_2$
12. **return** the reduce feature vector. (9000x3)

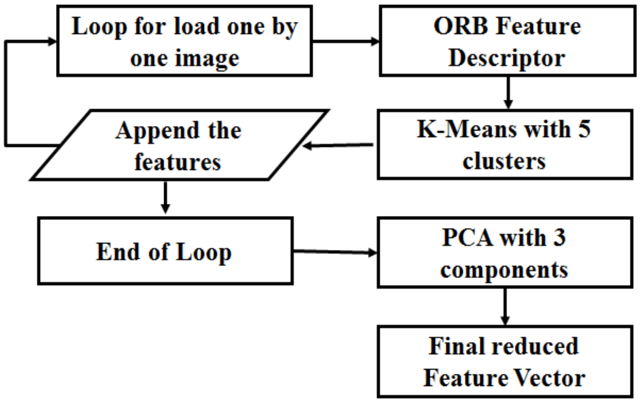

Fig.9. Algorithm 1 Flowchart

Algorithm 2: Object Detection.

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Input:- Image frames.
Output :- Object detection with audio.

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1. **while loop()** continuous
2. Input image frame by frame.
3. **Preprocessing**.
   resize(): 280x430 pixel. grayscale.
4. **ORB** feature extraction.
5. **K-Means** clustering
   N dimensions 1x5.
   Normalization.
6. **PCA**
   Reduce dimensions 1x3.
7. Applied to the trained classier to detect the object .
8. **if (car = = 1)**
9. Voice alert car detected.
10. **End if**
11. **if (person = = 1)**
12. Voice alert person detected.
13. **End if**
14. Again go to the while loop.
15. **End**

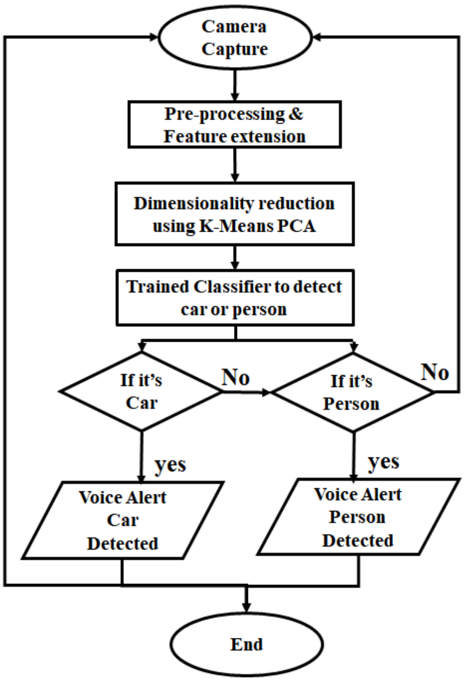

Fig.10 Algorithm 2 Flowchart

RESULT

Table.2. Classifiers Evaluations.

	Classifiers				
Test parameter	Decision tree	Random forest	SVM	Logistic regression	KNN
Accuracy	89%	90%	81%	81%	85%
Precision	86%	88%	80%	85%	86%
Recall	93%	94%	82%	82%	84%
Sensitivity	86%	86%	78%	78%	88%
Specificity	94%	96%	83%	83%	85%
F1 score	90%	91%	82%	81%	85%

As a data is randomly split into 80% for training and 20% for testing from random images to check the model performance. Table.1 illustrated the classifiers accuracy . The Decision tree algorithm give us an 89% accuracy. The Random Forest algorithm gave accuracy 90%. SVM gave us an algorithm of 81%, Logistic Regression algorithm gave us an algorithm of 81%. KNN gave us an algorithm of 85%. To order to summarize the performance of algorithm, it would be better to used confusion matrix. Different evaluation methods such as Specificity, Sensitivity, Recall, F1 Score were is also considered. A precision of 88% and a recall of 94% were observed. Therefore after using the values of Recall and Precision, the Fl score was equal to 91%. 90% accuracy was achieved by Random Forest as a classifier. Different predictions values were experimented on and the results were varied. Random forests have a certain number of trees, generally proportional to the number of rows in a dataset. After evaluating the performance of all 6 classifier Random forest is a best classifier, As show in the Table.2. Different evaluation method such as Specificity, Sensitivity, Recall, F1 Score were is also considered.

In real-world applications, the proposed system has great utility. Our dataset was based on several factors that contributed to its accuracy. Hardware that is very light can also be used to develop this system. That makes it extremely portable and convenient to use.

As needed, we will also provide audio output using wired earphone. Thus, the system offered is very user-friendly for visually impaired individuals and makes for excellent travel aid.

CONCLUSION

Those who are visually impaired need help, such as canes or guide dogs. In this work Real-time object detection and voice alerts system is developed to make visually impaired individuals to be more independent. Smart glasses presented in wearable technology, which are designed to make life easier for the blind and visually impaired. A user's smart glasses can detect obstacles and give them an audio alert. Using this system, visually impaired people can detect persons and cars. This system can be extended to include more objects for recognition and give a complete solution for blind person mobility. We plan to increase our training datasets there by making our system more robust toward object detection. By providing visually impaired people with independent transportation, navigation, and daily activities, we aim to improve their quality of life.

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